Nurturing the gene pool: national strategies for crop wild relative conservation and use


Pre-breeding – fishing in the gene pool
12th June 2013, Alnarp, Sweden

www.pgrsecure.org
Overview

- Why conserve crop wild relatives (CWR)?
- Developing a national CWR conservation strategy
  - Creating the national CWR inventory
  - CWR prioritisation
  - Current conservation measures
  - Priority ‘hotspots’ for CWR conservation
  - CWR conservation action plans
Why conserve CWR?

- **They are useful**
  - IPCC (2007) estimates that by 2100, wheat yields 40% in Europe unless climate change mitigation is undertaken
  - CWR are rich in genetic diversity and provide potential resistance to biotic and abiotic stresses (e.g. P&D, drought, flooding, extreme heat, salt)
- **They are threatened**
  - 27–42% loss of plant spp. in Europe by 2080 due to climate change (Thuiller et al. 2005)
  - 16–22% of Arachis, Solanum and Vigna CWR extinct by 2055, others have reduced range (Jarvis et al. 2008)
  - 16% of priority European CWR threatened with extinction; brassicas, beet, lettuce, wheat and onion gene pools of particular concern (Kell et al. 2012)
- **They are not well conserved**
  - 9% of European ex situ accessions of wild origin, these represent only 6% of CWR in Europe (Dias et al., 2012); CWR vastly under-represented
  - How many in situ genetic reserves in Europe meet Iriondo et al. (2012) guidelines? None?
Establishing CWR networks

- Numerous diverse approaches that result in CWR conserved in (and outside) genetic reserves

- Basic geographic scope:
  - Individual
  - National
  - Regional
  - Global

  Holistic approach to conservation

- Each concludes with CWR diversity being actively conserved *in situ* in genetic reserves or less formal conservation sites and *ex situ* storage for use
Floristic Approach

National CWR Conservation Strategy

- National CWR checklist
- Taxon prioritization
- Diversity and gap analysis
- Develop conservation action plan
- Implement in and ex situ conservation
- Promote CWR characterization and use

CWR are a unique national resource; each country has unique CWR resources due to ecogeographic partitioning of genetic diversity.
The objective is to maximize the conservation of the taxonomic and genetic diversity of the country’s CWR flora

Diversity and gap analysis leads to identification of complementary priority conservation actions

Genetic reserves established within existing national PAs (and/or new reserves established)

Germplasm collection and conservation in *ex situ* collections

Conserved CWR diversity is available for characterization and use in crop improvement

**Floristic Approach**

**National CWR Conservation Strategy**

Progress in Europe: Belarus, Czech Republic, Cyprus, Finland, Germany, Ireland, Italy, Norway, Portugal, Spain, Switzerland and United Kingdom
National / Regional Botanical Diversity

- Floristic checklists
  - Listed in Davis *et al.* (1986) and Frodin (2001)
  - Neighbouring country
  - Broader region (e.g. Flora Europaea)
  - For Bulgaria – Jordanov *et al.* (1963 -)

- Taxonomic checklist of country taxa
  - For the UK – 2,300 species
  - For Bulgaria – 5,087 species
1. National CWR checklist

- PGR Forum methodology (Kell *et al.*, 1995)
  - National floristic / taxonomic checklist
  - National crop checklist
  - Matching of genera
  - Extraction (data mining) of CWR taxa
- Uses generic definition of CWR

![Diagram of CWR checklist process]

- Crop genus names Manfeld’s Database
- Medicinal and aromatic genus names MAPROW
- Ornamental genus names CPVO Database
- Country Filter
- National CWR Checklist for Country X
1. National CWR checklist

‘Floristic route’ = Flora to crops to CWR inventory (semi-automated)

World Database of Crops

Regional Floristic Checklist

Digitised Matching

Regional CWR Checklist

Country Filter

National CWR Checklist

‘Monographic route’ = Crops to flora to CWR inventory (via workshop)

National Crop Checklist

Manual Matching

Generic Botanical Checklist

CWR in priority crop genera

National CWR Checklist

Is there a digitised Flora available (www.efloras.org)?
2. Selection of priority CWR

- Broad CWR definition with generic limit = relative large number of taxa (c. 80% of the European flora)

- Limited resources so need to focus on priority CWR
  - Current conservation status, socio-economic use, threat of genetic erosion, genetic distinctiveness, ecogeographic distribution, biological importance, cultural importance, cost, sustainability, legislation, ethical and aesthetic considerations, and priorities of the conservation agency
  - Economic value of crop (Global/regional/national production /economic value statistics / IT Annex 1)
  - Relative CWR relatedness (GP1b/GP2 or TG1b/TG2/ TG3) see http://www.cwrdiversity.org/checklist/
  - Relative threatened status (Red List status/known threats/limited distributions)
  - Native status
From checklist to inventory

a brush with nomenclature:

- **Complete CWR checklist** – a full list of all CWR found in a certain geographic area; simply a list of names and authorities.

- **Annotated CWR checklist** – a full list of all CWR found in a certain geographic area, but here additional information has been added to the list of names and authorities to aid prioritization of the checklist.

- **Priority CWR checklist** – a partial list of CWR found in a certain geographic area that has been reduced in number from the complete CWR checklist through prioritization, but is still simply a list of names and authorities.

- **CWR Inventory** – a list of priority CWR taxa that has ancillary information added for each CWR included in the inventory.
National CWR conservation strategy for Spain

- Spanish PRIORITY CWR Checklist: 938 species in 4 categories
  - FOOD – 226 species in 33 genera (12 families)
  - FODDER & FORAGE – 262 species in 12 genera (2 families)
  - ORNAMENTAL – 240 species in 5 genera (5 families)
  - INDUSTRIAL – 210 species in 10 genera (7 families)

- Spanish National Inventory: 492 CWR species
  - 324 species in the PGRFA group (food + fodder&forage)
  - 168 species in the ornamental group
  - Industrial group – ongoing prioritization
3. Gap analysis of priority CWR

Comparison of natural *in situ* CWR diversity with diversity sampled and conserved *in situ* or *ex situ* (Maxted *et al.*, 2008; Ramírez-Villegas *et al*. 2010)

Step 1: Circumscription of target taxon and target area

Step 2: Natural *in situ* diversity

2a - Taxonomic diversity assessment
2b - Genetic diversity assessment
2c - Ecogeographic diversity assessment
2d - Threat assessment

Step 3: Current conservation

3a - *In situ* techniques
3b - *Ex situ* techniques

Step 4: Setting priorities for future conservation action

4a - *In situ* conservation priorities
4b - *Ex situ* conservation priorities
Recommendations for CWR complementary conservation in Spain

Spanish National Inventory: 492 CWR species

- **In situ** gap analysis – PGRFA group
  - Accurate distribution data for 286 species
  - 44 ± 24% (Mean ± SD) of the populations located within existing protected areas (PAs)
  - 17 species have no known populations within PA

- **Hotspots and complementarity analysis**
  - 3 locations with 54–66 species
  - 19 locations with 41–53 species
  - 15 locations hold 71.68% of PGRFA CWR (Iterative selection procedure DIVA-GIS)

- **Ex situ** gap analysis – PGRFA group
  - 233 species (72%) have accessions in gene banks
  - 103 species have more than 10 accessions

Richness map for the PGRFA group (10x10 km grids).
Proposal for complementary conservation actions

CWR conservation action plans

5. Festuca arenaria Osbeck

**Family:** Fabaceae/ Leguminosae

**Synonyms:** F. juncifolia, Chaub.  
F. rubra ssp. arenaria (Osbeck) F. Aresch.  
**Common name:** Rush - Leaved Fescue

**Proposed red data category:** CR B1ab(i)

1. **Introduction**

1.1. **Ecogeography**  
Extensively rhizomatous perennial found on sand dunes and open sandy shingle. Also, more rarely, found on cliff-tops, ledges and rough ground near the sea. On sand dunes it typically occurs on semi-mobile foredunes dominated by Ammophila arenaria or Leymus arenarius. Grows in lowland altitudes. (Preston, et al., 2002).

1.2. **Description**  
Culms to 75cm, scattered; rhizomes very long, sheaths fused more or less to auricles. Ligules less than 1 mm; spikelets 8-14mm; upper glume 3-9 mm with awns 0.5-2.5 mm. (Stace, 2001).

1.3. **Current status**  
The 1962 Atlas survey underestimated the distribution of this species which now includes both F. juncifolia and F. rubra subsp. arenaria. (Preston, et al., 2002). In Ireland, there is one site possibly left in the Bull Island, Co. Dublin, where the species was last recorded in 1970. (Dooghe, et al., 1998).

1.4. **Economic importance**  
It is listed under agricultural/ horticultural crops in Mansfeld database

2. **Current factors causing loss or decline**  
Population pressure and habitat loss. The Bull Island population is threatened by development, population pressure and trampling. Threats to the Island habitats relate to public use of the island, water quality in Dublin Bay and invasion of the saltmarsh by Spartina anglica. (www.wetlands.org)

3. **Current action**

3.1. **Protection**  
The species is not on the Irish Red Data book, nor is it protected by law.

3.2. **In situ conservation**  

3.3. **Ex situ conservation**  
Not in ex situ collections at present.

3.4. **Monitoring and site management**  
The Bull Island is mainly managed as a recreational island and used by public for day visits, education and golf. The monitoring and research concentrates on pollution and water quality, sedimentation rates and salt marsh succession. (www2.unesco.org). Dublin Corporation manages the site by wardening system. The dunes have been stabilized by planting of Ammophila. Spartina anglica invasion is controlled by herbicides. (www.wetlands.org)

4. **Proposed actions**

4.1. **Policy and legislation**  
- Review the species protection status in the Flora Protection Order and review the IUCN red data category.

4.2. **Site safeguard and management**  
- By 2006, ensure that the management plan for the site includes prescriptions for the species conservation.  
- By 2009, secure favourable management of the site taking into account the needs of Festuca arenaria and include a monitoring program.  
- By 2009, ensure that any factors in the site causing decline of Festuca arenaria are eliminated.

4.3. **Species management and protection**  
- By 2008, publish a species-specific management plan for the conservation of Cardamine impetens.  
- By 2006, collect seeds for ex situ conservation in the Irish Threatened Plant Genebank. Trinity College Botanic Gardens and duplicate the collections with e.g. the Millennium Seedbank, UK.  
- By 2006, ensure the maintenance of ex situ living collections in the Trinity College Botanic Gardens and the
5. Implement **in situ / ex situ** conservation


- *Allium schoenoprasum*
- *Allium ursinum*
- *Asparagus officinalis subsp. prostratus*
- *Beta vulgaris subsp. maritima*
- *Daucus carota subsp. gummifer*
- *Raphanus raphanistrum subsp. maritimus*
- *Trifolium occidentale*
- *Trifolium repens*

Progress in Europe: Azerbaijan, Belarus, Bulgaria, Cyprus, Czech Rep., Finland, Greece, Ireland, Italy, Portugal, Norway, Spain, Sweden and United Kingdom
5. Implement *in situ* / *ex situ* conservation

Monitoring progress in Europe

Horizon scanning in Madeira (2010)

Review of progress available on-line at:

http://www.pgrsecure.bham.ac.uk/sites/default/files/documents/helpdesk/Progress_national_CWR_and_LR_conservation_Europe.pdf

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>National checklist</th>
<th>List of priority taxa</th>
<th>Threat assessment</th>
<th>Gap analysis</th>
<th>National action plan/strategy</th>
<th>Information system</th>
<th><em>in situ</em> conservation of priority taxa</th>
<th>Protected area (PA)</th>
<th>Genetic reserve</th>
<th>Outside PA</th>
<th>Ex <em>situ</em> conservation (priority taxa)</th>
<th>Legislation/policy</th>
<th>National utilization</th>
<th>Public awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albania</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>First draft</td>
<td>No</td>
<td>–</td>
<td>No</td>
<td>Partial</td>
<td>No</td>
<td>Partial</td>
<td>Yes</td>
<td>Yes</td>
<td>Partial</td>
</tr>
<tr>
<td>Armenia</td>
<td>Yes</td>
<td>Yes</td>
<td>Partial</td>
<td>First draft</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Partial</td>
<td>Yes</td>
<td>Partial</td>
<td>Yes</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>Yes</td>
<td>Ongoing</td>
<td>New Red Book in prep.</td>
<td>No</td>
<td>In prep.</td>
<td>EURISCO</td>
<td>Yes, within 15 national parks</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Seed and field gene banks</td>
<td>Yes</td>
<td>Partial</td>
<td>Some</td>
</tr>
</tbody>
</table>
From national to regional and global *in situ* CWR conservation and use

Approaches building upon national strategies:

1. *Simple additive* – all national CWR conservation contributes to regional / global networks

2. *National selective* – national CWR conservation selected by each country (e.g. MAA or MAP)

3. *Authoritative national nomination* – national CWR conservation selected by international ‘authority’

4. *Authoritative regional / global nomination* – national CWR conservation included only if desired top down analysis

Possibly a mixture of these as in Europe, where combined 2 and 4 approaches are being used!
Towards a European CWR conservation strategy

- European Cooperative Programme for Plant Genetic Resources (ECPGR) *In Situ* and On-Farm Conservation Network established in 2000
- Two working groups:
  - Wild species conservation in genetic reserves
  - On-farm conservation
- Initiated EC-funded projects PGR Forum, AEGRO and PGR Secure
- Published CWR and LR conservation methodologies

www.ecpgr.cgiar.org/networks/in_situ_and_on_farm.html
www.pgrsecure.org/
Scientific approach to global CWR conservation: *in situ* conservation strategy

**Selected crops:** banana/plantain, barley, broad beans, cassava, cowpea, finger millet, maize, pearl millet, potato, rice, sorghum, sugar beet, sweet potato and wheat

FAO – *Global Network of CWR Genetic Reserves* (Maxted and Kell, 2009)

Mimas, Sweida, Syria
Scientific approach to global CWR conservation: *ex situ* conservation strategy

- Global Crop Diversity Trust project  
  (Norwegian govt. funding)
- Primarily use orientated, but *ex situ* collecting in first 5 years:
  1. List of gene pools and taxa to collect 26 + 66 (92) genera with crops
  2. Ecogeographic data collection
  4. Field collection
  5. *Ex situ* storage
FAO national CWR ‘resource book’

- **Aim:** A *conservation resource book* to aid national PGRFA programmes in the preparation and enactment of national strategies for CWR and LR conservation

- Provides an *interactive array of options* for national PGRFA programmes to formulate and enact national strategies for systematic CWR and LR conservation to enhance CWR and LR exploitation and engender national and global food security

Draft available on-line at
CWR and LR information gateway

- Trait information (including phenomics, genomics and transcriptomics data)
- Baseline biodiversity information
- Diversity and its conservation
- Links with existing information systems relevant to PGRFA
- Predictive characterization (e.g. FIGS)
- Mapping / visualization

- Sourcing desired traits
- National CWR & LR checklists and inventories
- Gap analysis
- PA designation / targeted collecting
- Conservation strategies
  - National
  - Regional

Scalable to
- Other regions
- Global
Conclusions

- Increased global awareness of the importance of CWR conservation and use, particularly due to climate change and the need for food security

- Primary conservation of CWR will be via genetic reserves in PAs, but also require in situ conservation outside of PAs, with complementary ex situ holdings

- Knowledge and expertise is available to implement a holistic CWR conservation strategy for each country in Europe that could contribute to a global network of CWR genetic reserves

- CWR use can benefit individual European countries, as well as Europe as a whole, they are a unique national and regional resource